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(54) **Crop metering device**

(57) A crop metering device measures by volume the clean crop yield of a combine harvester during harvesting, wherein a trap 40 is located in the clean crop flow to build up a head of clean crop, and a paddle wheel 46 or analogous device successively releases known volumes of crop at a rate which tends to maintain a predetermined head of crop above the trap. A sensor 50 determines when the head of crop has built up to the predetermined level, and initiates successive operations of the paddle wheel or analogous crop releasing device. The volumes released are counted by a switch 52 or the like to determine yield in relation to time or harvested area. A weighing device (110), fig. 5 (not shown) may be incorporated to enable an on-board computer to effect volume-to-weight conversion.

FIG. 2.

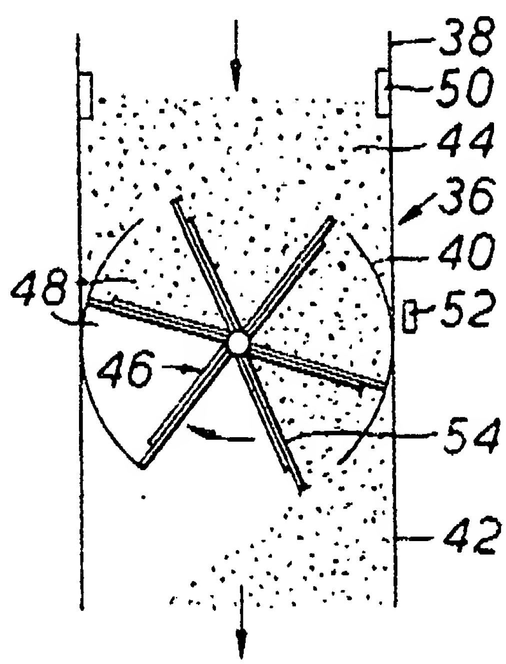

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FIG.1.

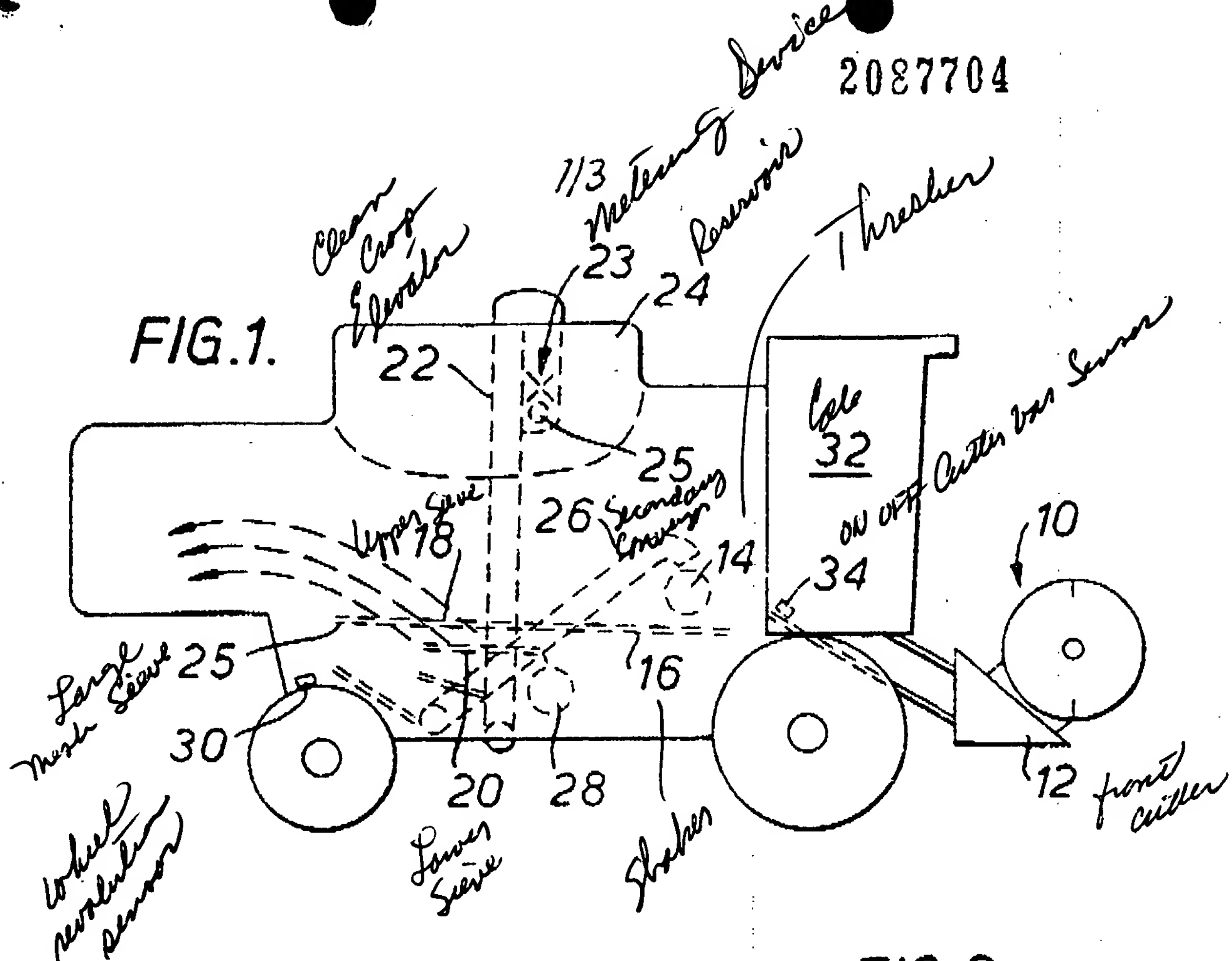

FIG.2.

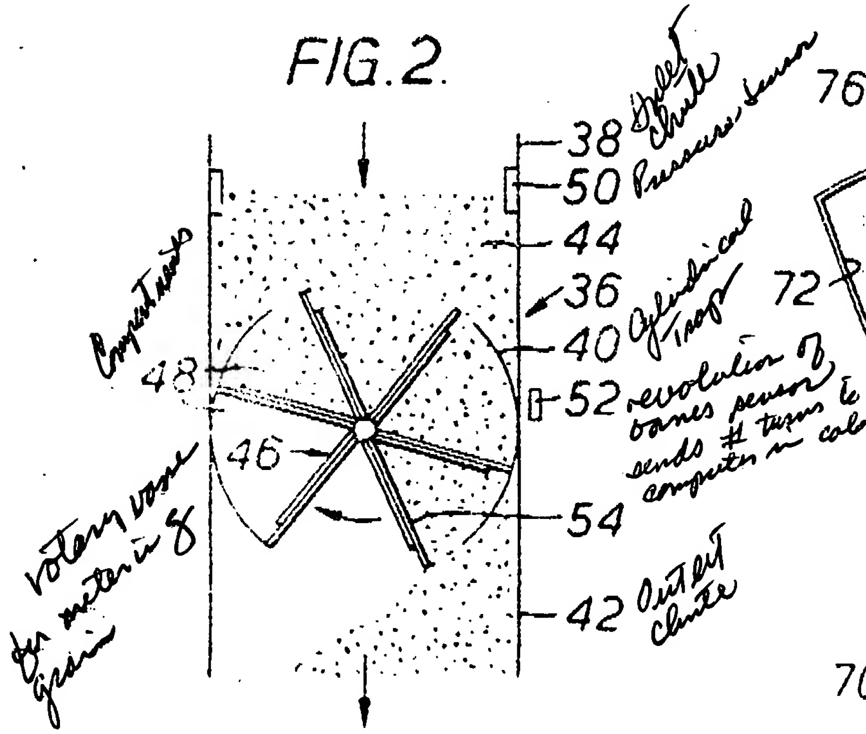

FIG.3.

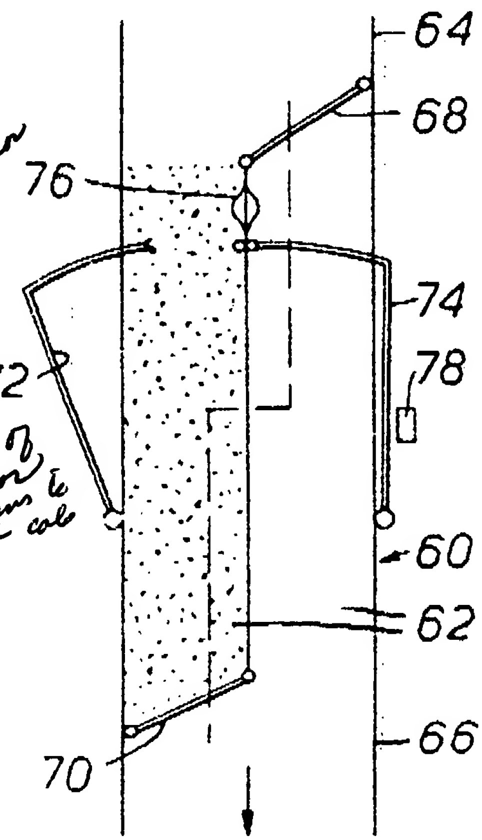

FIG. 4.

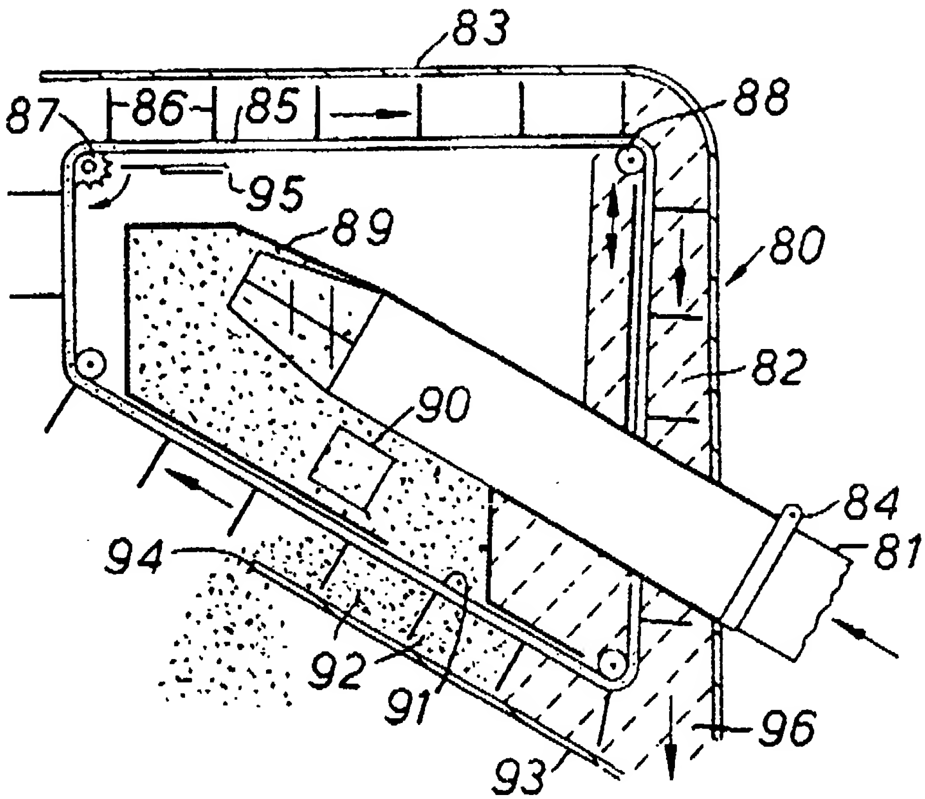

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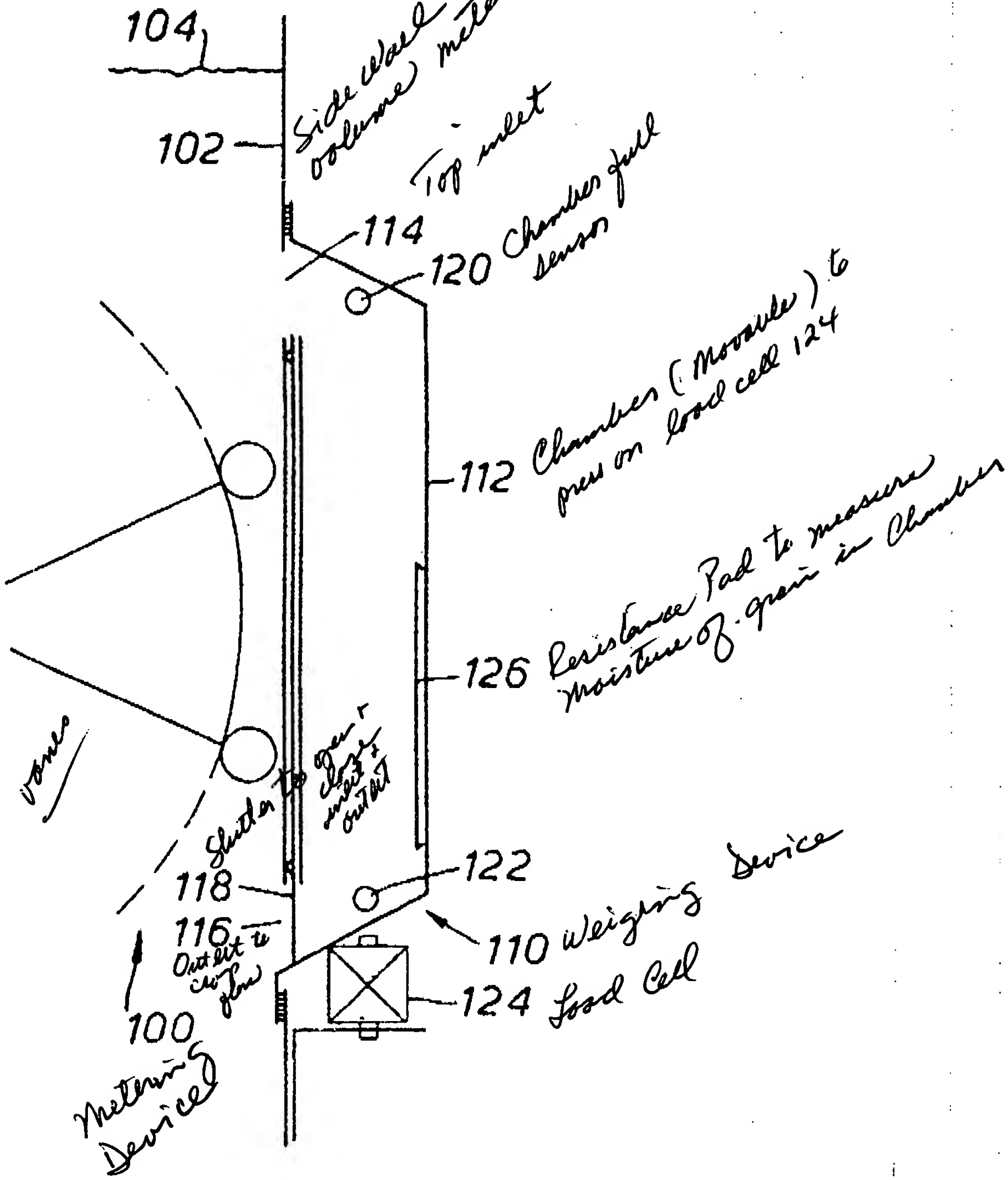
FIG. 5.



SPECIFICATION

Crop metering device for combine harvesters

This invention relates to a crop metering device for combine harvesters.

When a crop is harvested with a combine harvester, the operator is not readily able to determine the amount of clean crop being gathered in relation either to the area of ground being covered or the time being spent. This can only be determined subsequently, by physically weighing the crop obtained over a measured acreage during a given period of time. The only assistance given in this respect is by an area indicator, which is provided in some combine harvesters to provide a cumulative measure of the acreage which has been harvested.

At the present time, however, with various aids in the way of fertilisers and weed, pest and disease controllers available to farm management, it is very frequently required to subdivide the total area of the crop into smaller areas, e.g. by use of tramlining techniques, which smaller areas are treated differently from one another to test the effect of differing amounts and differing types of chemical aids. The results of differing treatments can only properly be assessed by the crop yield, but with existing crop measuring techniques it is extremely difficult for a farmer accurately to determine by experiment the treatment or treatments which are best suited to his land and farming methods.

In the prior art, U.K. Specification No. 1378715 discloses an arrangement in which, for example by the use of collecting containers together with sensors for measuring the extents of filling thereof, the quantity of harvested material is compared with the quantity ejected to waste. Analogously, in U.K. Specification No. 1270535 two compartments are alternately supplied with grain for predetermined periods and optical sensors are used to detect the extents to which the compartments are filled.

According to the present invention, there is provided a crop metering device for combine harvesters, located in the clean crop flow from the sieve pan up to the tank, and comprising a trap for creating the build-up of a head of clean crop, a sensor for determining when the head has built-up to a predetermined level, means responsive to said sensor for initiating release of crop from the built-up head thereof at a known rate, and means for relating the known rate of release to the maintenance of the head at said predetermined level in order to measure the amount of crop being harvested by volume.

In a preferred arrangement, a compartment of predetermined volume is filled by the head of crop, this predetermined volume is released under the control of the sensor, and the successively released predetermined volumes are counted. Conveniently, a paddle wheel may be divided in segments to form a succession of said compartments of known volume.

It is alternatively possible to use a device such as an auger to release crop from the head for a time period initiated by the level sensor. Since with the head of crop behind it, the auger will always operate full, the volume of crop released by the auger in a measured time period is also known. The auger may always be driven for the same time period, selected short enough to ensure that the auger always runs full; alternatively a second low level sensor may switch off the auger when the head of crop falls to a second, lower, predetermined level.

The above-described invention essentially differs from the prior art methods for measurement of harvested crop (corn, legumes or herbage seed in particular), by metering the clean crop by volume as it is released from a trap adapted to maintain a head of said crop.

Conversion of volume to weight can be effected by manually weighing a given small volume of crop and proportionately scaling the volumetric output of the metering device. This conversion may be effected electronically by feeding the preliminary weight measurement into a calculator. Alternatively, in accordance with another aspect of the invention, this volume to weight conversion may be effected automatically by weighing the small volume of crop within the harvester itself and feeding this output into a calculator which already receives the volumetric measurements from the metering device.

Thus, in accordance with this aspect of the present invention, a portion of the clean crop flow is diverted into a weighing device which comprises a chamber of known volume which is filled with the crop, a load cell at the bottom of the chamber to provide an output signal for a predetermined time period while the chamber is full, means for integrating said output signal to derive a measure of the weight of the crop in the filled chamber, and means for releasing the crop from said chamber back to the clean crop flow after completion of the predetermined measuring period.

In a preferred arrangement, the chamber is suspended to load the weight of the chamber on to the load cell, which is zeroed for the weight of the chamber when empty. Less desirably, the load cell may be loaded under a suspended bottom plate to the chamber, in which case a roller mounting of the complete chamber may be retained to reduce sensitivity of the device to vibration.

Preferably, a static volume of crop is maintained in the weighing chamber during the period of measurement, and to this end the chamber may include a high level, chamber-full, sensor and a low level, chamber-empty, sensor, and a top inlet to and a bottom outlet from the chamber may be controlled by a shutter means activated by the sensors. The high level sensor can also conveniently be used to initiate the measuring period, while opening of the bottom outlet may be controlled by a signal fed back from the integrator at the end of the measuring period. This period may be as little as a few seconds, or may be a number of minutes.

The automatic weighing device enables the user regularly to monitor the weight of crop being harvested, which can vary from one time to another owing, for example, to varying moisture content, which can cause one volume of crop to weigh differently to a subsequent equal volume.

Conventionally, corn measurements are based on

a moisture content of 16% or less. Thus, according to another aspect of the invention, the weighing chamber may include an electrical resistance pad for measuring the moisture content of the corn static in the chamber during the measurement period. The resistance pad may provide an output signal fed to the calculator receiving the output of the integrator in order to supply a moisture content correction thereto.

It is envisaged that the crop metering device of the invention will be applied to a harvester also equipped with a ground area indicator and a mini-computer will be provided in the cab with a read-out which will make available, in addition to the area indication, indications of any one or more of the cumulative crop volume and/or weight, the cumulative volume and/or weight per unit ground area, the current (i.e. running) volume and/or weight per unit ground area, and the area and crop volume and/or weight harvested per unit time.

Further features of the invention will be apparent from the following description of some practical embodiments of the invention, referring to the accompanying drawings, in which:

Figure 1 diagrammatically indicates the lay-out of a typical combine harvester;

Figures 2, 3 and 4 respectively show three differing embodiments of the volume metering device of the invention in diagrammatic form; and

Figure 5 shows a weighing device attached to one side of a volume metering device.

In the typical harvester of Figure 1, the crop is cut by a front cutter assembly 10 including a cutter bar 12, which can be retracted upwardly to stop harvesting when necessary, e.g. when the harvester is turning at the edges of a field or is being manoeuvred. The cut crop is taken to a thresher 14, thence dropping on to a shaker assembly 16 leading rearwardly to an upper sieve 18 from which the clean crop drops through a lower sieve 20 (sieve pan) on to a mai elevator 22 which lifts the clean crop to an exit from which the crop falls into a reservoir 24 (tank). Partially cleaned crop not passing through the first part of the upper sieve 18 passes to a larger mesh sieve 25 from which this material falls onto a secondary conveyor 26, which also receives partially cleaned crop rejected by the sieve pan 20, whence this material is recycled through the thresher 14. A blower 28 below the sieves blows chaff or like lightweight rejected material out of an exit at the rear of the harvester.

The metering device of the present invention can be located anywhere in the clean crop flow between the sieve pan 20 and the tank 24, i.e. between the sieve pan 20 and the main elevator 22, at a break in a two-part main elevator 22, or between the exit from the main elevator 22 and the tank 24. In Figure 1, the metering device, generally referenced 23, is shown located at the top of the main elevator 22 above a tank elevator 25.

It is proposed that the crop metering device will be used with an area indicator, conveniently of a conventional kind which comprises a revolution sensor 30 on a rear wheel of the harvester, a computer/indicator (e.g. a counter with digital read-out) in the cab 32 which can be programmed for cut width, and an on/off cutter bar sensor 34 operative to interrupt area measurement when the cutter bar 12 is raised.

One embodiment of the metering device of the invention is shown in Figure 2. This device, generally designated 36, has a vertical inlet chute 38 receiving the total flow of clean crop from the direction of the sieve tank (e.g. at the main elevator outlet), a cylindrically shaped trap 40 fed through the inlet chute 38, and an outlet chute 42 discharging released and metered crop into or towards the reservoir tank (e.g. via the tank elevator). The crop 44 is metered by the combination of a paddle wheel or rotary vane assembly 46 within the cylindrical trap 40, which vane assembly subdivides the trap into a plurality of equal compartments or segments 48, together with a pressure sensor 50 (preferably one on each side) in the inlet chute 38. The vane assembly 46 is driven in rotation (by a belt drive or other mechanical, electrical or hydraulic transmission taken or derived from a power take-off on the harvester) only when the pressure sensor 50 is operatively switched on due to the pressure of crop accumulated in the inlet chute 38. When the vane assembly 46 is driven, one or more compartments 48, previously filled with crop from the inlet chute 38, are emptied through the outlet chute 42. At the same time, empty following compartments 48 are filled from the inlet chute 38, so that the crop level falls in the said inlet chute below the level of the sensor 50, which is thus switched off, whereby the vane assembly 46 is stopped. Crop then builds up again in the inlet chute 38.

Obviously, the pressure sensor 50 can be replaced by a photoelectric sensor or any other kind of sensor capable of sensing that the crop has built up to a predetermined level in the inlet chute 38 and of providing an output for initiating operation of the vane assembly 46.

In accordance with the invention, the compartments 48 of the trap 40 have a predetermined known volume, and the revolutions (or given partial revolutions) of the vane assembly 46 are counted. Preferably but not essentially the revolutions of the vane assembly 46 are sensed by a magnetic or electronic switch 52, which supplies one electrical pulse for each one or for each of a plurality of compartments from which the crop is released. If, for example, the switch is a revolution counter such that one pulse is produced per complete revolution of the vane assembly, each pulse will represent a flow into the tank of a volume of crop equal to six times the known volume of an individual compartment 48. The essential requirement for accuracy is that crop will only be released out of completely filled compartments 48 in the trap 40, and it is desirable for this reason to locate the pressure sensor 50 some distance above the trap, so that a greater or lesser head of crop will remain in the inlet chute 38 above the trap 40 at all times.

It is envisaged that the individual vanes 54 of the vane assembly 46 will be metal backed nylon plates to ensure relatively tight engagement with the cylindrical wall of the trap 40 sufficient to prevent leakage, whilst offering sufficient flexibility to yield under a pressure which could otherwise cause jam-

ming, as might arise due to the presence of small stones or other foreign bodies in the nominally clean crop flow. Vanes 54 comprising metal plates faced with rubber at their outer edges may alternatively be employed, or possibly the wall of the trap may be resiliently mounted in the chute 38, 42 to minimise risk of jamming.

In the driving cab, a mini-computer will incorporate the conventional area indicator and will receive the electrical pulses from the revolution sensing switch 52. This computer will have a digital read-out, and be programmed in a permanent memory for calculating functions and a volatile memory for variable factors such as volume to weight converters. The latter conversion is dealt with later in connection with a crop weighing device which may be used in conjunction with the volume meter. Three digital readouts are envisaged, one for area, one for volume and/or weight, and one (possibly longer) for selective display of any of the possible computed measurements which have previously been mentioned.

An alternative embodiment of the invention is shown in Figure 3. The rotary trap 40 of Figure 2 is replaced by a straight flap-type trap 60 having two vertical compartments 62 side-by-side which are filled alternately from the inlet chute 64 and when full alternately release the crop into an outlet chute 66. Coupled top flap 68 and bottom flap 70 control the crop flow, one compartment always being closed over the top when the other is closed at the bottom. The top of the compartment of predetermined volume is defined by a pair of cut-off flaps 72 and 74. A pressure sensitive switch is indicated at 76; this may be pressure sensitive on both faces, or two sub-switches may be employed. Assuming the switch 76 responds to a head of crop above the left-hand compartment 62, the cut-off flap 72 is moved in, penetrating the crop to enclose a predetermined volume of the crop above the bottom flap 70 which is closing the bottom of the left-hand compartment. On completion of movement of the cut-off flap 72, e.g. as determined by a second sensor, the top and bottom flaps 68 and 70 are switched over, releasing the predetermined volume of crop from the left-hand compartment. Completion of the movement of these flaps, e.g. as determined by a third sensor, causes the cut-off flap 74 in the right-hand compartment to move out, allowing the right-hand compartment, now closed at the bottom, to fill from the inlet chute 64 until a head builds up to operate the pressure switch in response to a head of crop above the right-hand compartment 62.

The number of predetermined volumes of crop which are being released can be counted by a suitable magnetic or electronic switch 78 responsive to the movement of one of the flaps. Alternatively, the operations of the pressure switch 76 can be counted.

A third embodiment of the invention is indicated in Figure 4. This metering device, generally designated 80, is expected to be mounted in the tank at the output end of the tank elevator 81. A frame 82 including a top guard 83 is mounted to the elevator 81 by a clamp 84. An endless chain 85 carrying spaced flaps or paddles 86, e.g. of rubber, is driven from a power output of the harvester, e.g. hydrostatically or electrically. The reference 87 denotes a driven sprocket and reference 88 denotes a sprung guide roller. Within the loop defined by the endless chain 85, the crop is emptied from the tank elevator 81 into a chamber (trap) 89 containing a pressure sensor 90. When a sufficient head of crop builds up to activate the sensor 90, the chain 85 is driven. Crop exits through an opening 91 at the bottom of the chamber 89 to enter spaces 92 of known volume defined between successive paddles 86 by a bottom guard 93. The crop contained within these filled spaces is conveyed by the chain drive when operative to the upper end 94 of the bottom guard 93, where it is released to fall into the tank. A counter 95, e.g. associated with the drive sprocket 87, in effect counts the number of known volumes of crop being released. When the head of crop in chamber 89 falls below the pressure or other suitable sensor 90, the drive of the chain is stopped until the head of crop builds up again. The arrangement permits the tank to fill to the top, where the top run of the chain is located, since a small flow of crop along the top run of the chain and down the right-hand run thereof, which is open at the bottom 96, does not substantially affect metering.

In all embodiments, an over-ride switch will be provided in the driving cab to enable the crop metering device to be rendered inoperative. This over-ride switch is necessary to enable the trap to be emptied, at the end of a harvesting operation, without falsely increasing the measurement of the amount of crop due to the counting of operations of the trap when the compartment or compartments are not full.

While three practical embodiments of the volume metering device of the invention have been above described, various modifications are possible generally in accordance with the basic concept of metering crop flow in a combine harvester by volume, utilising a compartmented trap in the clean crop flow which is operated under the control of a sensor which determines when a compartment is full before permitting the crop in said full compartment(s) to be released. Such a concept does not exclude the possibility of using a continuously variable sensor, e.g. a potentiometer, which through a variable speed motor or the like continuously varies the rate of release of crop from the compartmented trap, i.e. the speed of the vane assembly or chain, whilst maintaining a head of crop above the trap to ensure that crop is only released from filled compartments.

Referring now to Figure 5, a volume metering device, designated 100, is generally in accordance with the embodiment above described with reference to Figure 2. As already explained, the metering device 100 supplies an electrical output to a calculator or computer (in the harvester cab) which can provide to a visual display a measure of the volume of corn being harvested. A computer can be input with a weight conversion factor determined by manual measurement of the weight of a small known volume of corn. However, the device of Figure 5 enables a volume to weight conversion to be effected automatically during metering of the crop.

The weighing device of Figure 5 is generally designated 110, and comprises a chamber 112

mounted to the side of the volumetric meter 100. The chamber 112 is mounted to the side wall 102 of the volumetric meter 100 through suspension rollers which allow a limited up and down movement of the chamber, including all components carried by it, effectively to load the weight of the chamber on to a load cell 124 fixedly mounted beneath the chamber.

The chamber 112 has a top inlet 114 from the head of crop 104 above the volumetric meter 100, and a bottom outlet 116 back to the clean crop flow below said meter 100. Opening and closing of the inlet 114 and outlet 116 is effected by a shutter 118 movable up and down by an electromagnetic drive (not shown). Suitable means will be employed to prevent any crop becoming trapped in the narrow clearances between the inner wall of the volume meter 100, the shutter 118 and the inner wall of the weighing device. The shutter 118, it is to be noted, is carried by the main framework of the chamber 112 to be suspended therewith on the above-mentioned roller mounting.

Within the chamber 112 is a high level, chamber-full sensor 120 and a low level, chamber-empty sensor 122.

When the chamber 112 fills to the level of the sensor 120, integration of an electrical output of the load cell 124 is automatically initiated. Directly or indirectly, the load cell 124 is zeroed for an empty chamber 112, so that its measured output depends on the weight of crop in the filled chamber.

At the end of a predetermined time period, integration of the load cell output is terminated and a signal is fed back to the electromagnetic drive for the shutter 118, so that the shutter is lifted, thereby opening the bottom outlet 116 and closing the top inlet 114. The chamber 112 empties, and when empty the sensor 122 provides a signal to the shutter device for dropping the shutter, thus opening the top inlet and closing the bottom outlet. When a full chamber 112 is again sensed, a subsequent weighing measurement can take place.

The output of the integrator (not shown) is fed to a computer in the harvester cab which already receives a signal representing volume output, and a volume to weight conversion is effected to enable a weight measure of the crop being harvested to be displayed on the display device (conveniently an LED or LCD binary display unit).

Moisture content correction may be effected automatically in the computer by means of a moisture content signal fed from a resistance pad 126 located within the chamber 112. The moisture content signal is taken into account during the measuring period, when the crop is static within the chamber 112.

One particular point which should be mentioned in connection with the described arrangement is that integration of the load cell output over a reasonable time period is desirable to avoid or at least minimise errors due to vibration when the harvester is operational. The predetermined period will be selected to minimise such errors, and generally will not be less than a few seconds nor greater than a number of minutes. A shorter period possibly with increased risk of errors enables the weight of corn being harvested to be monitored more frequently, so that variations from one small area of a harvested field to another may be more readily detected. Generally speaking, however, it is variations between larger harvested areas which are more significant and the ability to be able to check the crop yield every few minutes is the maximum requirement.

Various modifications of the described arrangement of Figure 5 are possible within the scope of the invention. In particular, the term "load cell" as used herein should be broadly construed to include any convenient measuring device capable of producing an output dependent on the weight of the load to which it is subjected, such for example as a strain gauge. Again, in the described embodiment, one side of the load cell is fixedly mounted. However, this is not an essential requirement. It is possible, for example, to incorporate a counterweight or counterbalancing mechanism in the system to balance the weight of the weighing chamber, so that the load cell is subjected only to the weight of the crop. Such a modification may entail mounting at least one side of the load cell to a member forming part of the counterbalancing mechanism.

CLAIMS

1. A crop metering device for combine harvesters, located in the clean crop flow, and comprising a trap for creating the build-up of a head of clean crop, a sensor for determining when the head has built up to a predetermined level, means responsive to the sensor for initiating release of successive volumes of crop from the built up head thereof, and means for measuring the volumetric rate of release which tends to maintain said head at the predetermined level.

2. A device according to claim 1, wherein said crop releasing means is operative successively to release known volumes of crop at variable time intervals, and the measuring means comprises means for counting said known volumes of released crop.

3. A device according to claim 2, wherein said trap is a compartmented trap interrupting the flow of clean crop, the sensor is positioned to sense when the interrupted flow of crop has accumulated to a given excess upstream of a filled compartment of known volume, and the releasing means is operative in response to the sensor to release downstream the crop from successively filled compartments.

4. A device according to claim 3, wherein the trap and crop releasing means comprises a circular housing for a rotatable paddle wheel divided into segments to form in said housing a succession of said compartments of known volumes.

5. A device according to any of claims 2 to 4, wherein said known volumes are equal volumes.

6. A device according to any of claims 1 to 5, in combination with means for weighing a small known volume of crop and a calculating means for receiving measurement signals from the measuring means for volumetric rate of release and from said weighing means and for converting the volumetric measurement into a measurement by weight.

7. The combination according to claim 6, wherein the weighing means comprises a chamber

of known volume which is filled with successive samples of the crop, a load cell at the bottom of the chamber to provide an output signal for a predetermined time period while the chamber is full, means for integrating said output signal to derive a measure of the weight of crop in the filled chamber, and means for releasing the crop from said chamber after completion of the predetermined measuring period.

8. The combination according to claim 6 or claim 7, including a moisture content measuring means in the chamber from which is derived a correction signal for the measured weight.

9. The combination according to claim 7 or claim 8 when appendant to claim 7, wherein the weighing chamber has a high level, chamber-full sensor and a low level, chamber-empty sensor, a top inlet, a bottom outlet, and a shutter means activated by the sensors to control said inlet and outlet, the high level sensor being operative to initiate the measuring period and opening of the bottom outlet being initiated by a signal fed back from the integrating means at the end of the measuring period.

10. A device according to any of claims 1 to 9, in combination with a ground area meter, a computing means fed with measurement signals from said ground area meter and the measuring means for volumetric rate of release for computing the volumetric crop yield per unit ground area, and a display unit in the cab of the harvester fed with the output of said computing means.

11. A device according to claim 1, wherein the crop releasing means is operative successively to release crop at a known discharge rate during successive variable time periods which tend to maintain said predetermined head of crop, and the measuring means is operative to measure the lengths of said time periods.

12. A crop metering device for combine harvesters substantially as hereinbefore described with reference to the accompanying drawings.

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